APPENDIX EA.2. UPSTREAM EMISSION FACTORS FROM COAL AND NATURAL GAS PRODUCTION

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Tracking of pollutant emissions by the National Energy Modeling System (NEMS) used for the appliance energy efficiency standards analysis, called NEMS-BRS, is incomplete, with thorough treatment of some aspects and scant treatment of others.[a] The approach is also somewhat different between emissions. Overall, carbon emissions are well covered because they are estimated based on elemental carbon released as carbon dioxide (CO_2) from all hydrocarbon combustion. However, some energy-use effects of proposed standards are not tracked by NEMS-BRS so their effects on carbon emissions are not counted. For example, the effect of lower residential electricity consumption on generation is estimated, but not the second order effect on energy consumed in coal transportation to power plants.

In other words, the amount of energy used to perform the upstream processes in coal and natural gas production is not linked to the downstream consumption of these fuels. For this reason, while total carbon emissions are counted, changes due to proposed standards are not. According to DeLuchi, the amount of energy used to mine and clean the coal is minimal, amounting to less than 1% of the energy available in the coal. The amount of energy required to transport the coal using trains, trucks, and pipelines is approximately 0.156 exajoules/annually (EJ/a) or 0.148 Quads/a as estimated for the year 2000.[1] Based on the AEO99 energy consumption of coal from electric generation, this corresponds to 0.7% of the total energy required by electric generators. For natural gas production, the amount of energy used to transport natural gas to the end-use consumer is 3.5% of the total natural gas produced and made available to end-use customers as estimated for the year 2000. For extraction of crude oil, the relative percentage is only 2.8%. Thus, the upstream losses are small relative to the total amount of energy embodied in the coal, oil, and natural gas and, therefore, changes due to proposed standards are also likely to be small.

NEMS-BRS tracks only NO_x and SO_2 emissions from power generation. Sources of these emissions that may be affected by proposed standards are therefore missed. Two notable sources of NO_x and SO_2 emissions not considered are household emissions from the combustion of natural gas, liquefied petroleum gas (LPG), and heating fuel oil and emissions associated with fuel extraction and delivery to the point of combustion.

This analysis considers two uncounted emissions from coal and natural gas production and delivery, SO_2 and NO_x. These emissions include those due to the mining of coal or extraction of natural gas, the physical processes involved in preparing or cleaning the fossil fuel, and the transportation of the fuel from the mine to the power plant. Household combustion effects of

[a]For more information on NEMS, please refer to the U.S. Department of Energy, Energy Information Administration documentation. A useful summary is *National Energy Modeling System: An Overview 1998*, DOE/EIA-0581(98), February 1998. DOE/EIA approves use of the name NEMS to describe only an official version of the model without any modification to code or data. Because our analysis entails some minor code modifications and the model is run under policy scenarios that are variations on DOE/EIA assumptions, the name NEMS-BRS refers to the model as used here (BRS is DOE's Building Research and Standards office, under whose aegis this work has been performed).

proposed standards are explicitly included in the appliance energy-efficiency standards analysis and the methods used are described in Appendix EA-1.

Studies addressing upstream emissions are very limited. Thus, the reliability of the exact measurements can be easily criticized. The values presented here are only intended to provide a coarse estimate of the magnitude of upstream emissions not accounted for in NEMS-BRS. In general, emissions from mining, cleaning, or transporting fossil fuels are small compared to the emissions that result from their combustion.

Upstream emissions estimates for carbon and NO_x are taken from a thorough study done by M.A. DeLuchi at Argonne National Laboratory in 1993. DeLuchi provides estimates of full fuel-cycle emissions factors for emissions of CO_2, methane (CH_4), carbon monoxide (CO), non-methane organic compounds (NMOC), and NO_x from coal and natural gas production. An emission factor for SO_2 is taken from the United States Environmental Protection Agency's (EPA) Compilation of Air Pollutant Emissions Factors, AP-42.2 This source notes that coal cleaning is the primary source for upstream SO_2 emissions from coal production, so the emission factor for SO_2 only reflects the coal cleaning process. Transportation is not addressed in EPA's study.

Emission factor estimates and corresponding percentage contributions of the upstream emissions relative to power plant emissions are shown in Table EA-2.1 for carbon, SO_2, and NO_x from coal and natural gas production. The relative percentage to power plant emissions is provided so an estimate of upstream emission savings based on the savings from the power plant could be easily estimated. The values shown in Table EA-2.1 represent emissions from upstream processes as mass (g) of deliverable energy to end-use consumers.

Table EA-2.1 Estimated Upstream Emission Factors and Relative Percentages to Direct Power Plant Combustion Emissions

	Coal		Natural Gas	
	Emission Factor (g/GJ)	**% of Combustion Emissions**	**Emission Factor (g/GJ)**	**% of Combustion Emissions**
Carbon	2222	2.7	5456	11.9
SO_2	29.2	0.9	0	0
NO_x	41.7	5.8	153	40

DeLuchi's analysis reveals that upstream processes in coal production relative to power plant emissions account for 5.8% of NO_x and 2.7% of carbon. The AP-42 indicates that less than one

percent of SO_2 emissions result upstream relative to those from coal power plant emissions. Upstream coal processes, therefore, account for at most 6% of relative power plant emissions for carbon, SO_2, and NO_x.

For natural gas production, the upstream SO_2 emissions are negligible. The upstream emissions from NO_x, however, are quite significant, accounting for 40.0% of emissions relative to those from the power plant. Total natural gas combustion NO_x emissions from the power plant are only half those from coal, while emissions upstream processes are four times those of coal. Carbon emissions are nearly 12% of power plant emissions with an emission factor of 5456 g/GJ of deliverable energy; however, as noted above, changes to these emissions are counted by NEMS.

Relative to the entire fuel cycle, DeLuchi estimates that approximately 8% by mass of all emissions from coal production are due to mining, preparation, and transport from the mine to the plant. Transportation emissions include those resulting from the use of fuel by the modes of transportation used to move the fuel from the site of extraction to fuel production facilities. For natural gas production, 14% of total emissions are estimated to result from upstream processes. Based on Table EA-2.1, this higher loss factor in natural gas production is likely due to the higher NO_x contribution.

Thus, emissions factors and their relation to power plant emissions are provided to reveal the relatively small proportion of energy losses attributable to upstream processes. With the exception of NO_x emissions from natural gas production, all emissions are less than 12% of power plant emissions.

REFERENCES

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2. U.S. Environmental Protection Agency, *Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Chapter 11, Mineral Products Industry*,1995. November. <http://www.epa.gov/ttn/chief/ap42c11.html>